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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improved Magnetron for producing Very Short Electomagnetic Waves

We, "PATELHOLD" PATENTVERWERTUNGS- & ELEKTRO-HOLDING A.—G., of Glarus, Switzerland, a Swiss Company, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

In devices for producing very short electromagnetic waves the oscillation circuit of the generator is directly connected with the exciting mechanism. In retarding-field tubes the anode is usually connected to one conductor and the grid to the other conductor of a Lecher system serving as the oscillation circuit. It is particularly advantageous to use a hollow resonator as the oscillation system, because on account of its large conductive surface it has very low losses and is distinguished accordingly by high resonance over-voltages. Amongst these are to be understood the voltage values in the case of resonance, compared with those in the case of non-resonance.

The present invention deals with the problem of utilising the advantages obtained by connecting the exciting mechanism which is best as regards efficiency and which consists in electrons circulating perpendicularly to segments, with a cavity resonator which alone determines the frequency of oscillation. The invention thus concerns a magnetron for producing ultra-short electromagnetic waves and which is characterised by the provision for the oscillation system of a practically closed annular hollow body bounded in a radial direction by two cylindrical casings, the cylindrical casing nearer to the axis being divided along the entire cylinder periphery into two parts by a tortuous slot, said parts being at different alternating potential but at the same direct potential relative to the cathode located in the axis of the system.

An important fact as regards the present invention is that in a hollow resonator an electrical oscillation is excited by which in known manner a continuous conversion of capacity energy into inductive energy occurs. This procedure, which is analogous to the oscillation procedure of a transmitting antenna system, is capable of furnishing energy in the form of electromagnetic oscillations.

A number of constructional examples of the invention are illustrated diagrammatically in Figures 1—4 of the accompanying drawing.

Figure 1 shows a magnetron oscillator for generating ultra-short electromagnetic waves. The tortuous slot Z allows the segments S_1 and S_2 to stand out from the inner cylinder. These segments, together with the outer cylinder and the radial side walls form the hollow body H which acts as a hollow resonator, the segments mutually representing the capacity and the remaining part of the hollow body the inductance of the latter. When the hollow resonator oscillates the segments S_1 are positive and the segments S_2 negative at a certain instant. As a result of the oscillating process these charges now change places so that after a half cycle the segments S_1 become negative and the segments S_2 positive. For this change-over the hollow body H, which acts as an inductance, is used as the inductive connection. In order to make Figure 1 as clear as possible the cathode and control grid have been omitted from the Figure.

Figure 2 shows a sectional view of a magnetron generator in accordance with Figure 1 in a plane containing the axis of the generator. Figure 2 differs from Figure 1 in so far as a cathode K surrounded by a grid G is also shown, also that an energy conductor L for extracting the high-frequency energy is provided and finally, perpendicularly to the axis of the magnetron H, metal plates P_1 and P_2 are arranged for preventing the radiation of high frequency energy. The capacity of the oscillation circuit is again formed by the adjoining segments S, whilst the inductance is formed by that part of the hollow body H comprising the end surfaces and the outer cylinder.

Figure 3 illustrates a further embodiment of the invention developed from the construction illustrated in Figure 2. The cathode K is smaller and located in the

immediate vicinity of the side plate P_2. The side plate P_1 can be used as a control grid if it is insulated from the remaining parts of the device.

If with the arrangements shown in Figure 2 or 3 the side plates P_1 and P_2 are connected along the outer periphery in a vacuum-tight manner with the cavity, for instance by being soldered to the remaining part of the device an all-metal construction can be obtained, for the tube thus obtained is bounded by metal parts only with the exception of the bushings which naturally are not of metal but must be of an insulating material. Such a valve does not therefore require to be enclosed in a glass vessel, since it is already vacuum-sealed without such help.

The embodiment shown in Figure 4, with the exception of the bushings V, is a construction of this kind. The same reference letters are used for the same elements as in the previous Figure. Side walls are used here instead of side plates for protection against radiation. The plates located parallel to the side walls inside the cathode space serve as a screen inside the inner cylinder for the electrical field which occurs due to the anode potential at the said walls, thus preventing any undesirable deviation of the electrons.

Constructions according to the invention possesses several advantages. They have complete electrical symmetry as regards each segment pair. Due to heat being conducted to the side walls the thermal loading of the anode is reduced. The all-metal construction illustrated in Figure 4 is suitable for large powers because by constructing the resonator as a vacuum vessel it is possible to obtain a ready removal of heat from the anode. The wave length of the oscillation is determined by the mutual capacitance of the segments and the diameter of the hollow resonator. For the same wave lengths the dimensions of the generator according to the invention are larger than those of the known kinds of magnetrons. Particularly the actual external diameter of the anode is three to four times larger and this enables a better arrangement of the cathodes and control grids, even for small wave lengths. The larger radial dimension enables a spiral cathode to be used for high currents. Furthermore the axial dimension can be reduced to a minimum so that the pole shoes of the magnet need not be so far apart and therefore permanent magnets can be used. Since the wave length is determined by the mutual capacitance of the segments and the diameter of the hollow resonator this value is definitely fixed for a particular case. This is a considerable advantage when compared with a known construction where the wave length is not clearly defined. In this latter type of magnetron the inter-penetrating segments are formed into two groups by means of two short-circuiting rings, these groups being connected by a loop.

The invention is of course not restricted to the constructional examples described. A large variety of modified forms are possible. It is for instance not necessary that the entire device should be made of the same material. The inner slotted cylindrical surface can be made of special heat-resisting material, for instance tantalum, because this is subjected to a strong heating action due to the impact of the electrons.

The shape of the hollow space H can differ from that shown in Figure 1 by bevelling the sharp edges or providing the side surfaces with recesses. The inter-penetrating segments formed as a result of the zigzag slot can be made so narrow and thick that they finally become rods. The segments can be either soldered to the side walls of the hollow resonator, fitted into the resonator or fixed in any other suitable manner.

The cathode K is heated either directly or indirectly. Generally there is sufficient space to enable a large surface cathode to be used. The following arrangement originating from the construction shown in Figure 3 likewise constitutes a form of construction of the invention. The cathode is located outside the side plate P_2 and the electrons pass through a central opening in the plate to the inside of the magnetron generator. If the plate P_2 is also insulated it can serve as a control grid. Another construction is possible if the plate P_2 has a constant potential and a control grid is arranged over the aforementioned opening by means of which the intensity of the electrons passing through is controlled.

The all-metal construction is the most favourable as regards cooling, because it provides a maximum of metal surface. Generally both liquid and air cooling are employed, particular care being taken that the inner cylinder can readily get rid of its heat by means of a good and rapid conduction away from the side wall where the segments end. Since the segments are those parts of the tube which become most highly heated in operation it is advisable to effect the cooling in such a way that the heat is removed from the segments by as direct a path as possible. For this purpose the external surfaces along the fastening places of the inner cylindrical

casing in particular are artificially cooled.

In order to obtain full use of the magnet it is advisable to provide holes in its pole shoes into which the insulators V (Figure 4) lying in the axis of the magnetron can be fitted exactly and through which also the leads to the cathode can pass. By this means the poles are as near to each other as possible and the magnetic field therfore attains its maximum value. In order to insert the magnetron between the poles these must be moved apart and then pushed together again. This can for instance be achieved by making the magnet in two parts which can be fitted together.

By varying the volume of the magnetron at the places where the electric or magnetic field exists it is possible to obtain a variation in the frequency of the generator oscillations; that is to say by this means it is possible to vary its frequency. Therefore for instance by means of an elastic deformation of the walls at the points where there is maximum electrical or magnetic energy, it is possible to obtain a frequency variation. In the constructional example shown in Figure 4 the strongest electrical field is in the vicinity of the axis whilst the maximum value of the magnetic field is in the neighbourhood of the outer cylindrical envelope. The volume can also be varied by introducing a metal rod or piston into the inside of the resonator.

The Lecher line for extracting the energy also has an influence on the frequency of the resonator oscillation. A further possibility for a frequency variation of the hollow resonator is thus provided by varying the natural frequency of the Lecher line. For this purpose variable frequency-determining elements must be provided on the Lecher line. This is for instance the case when the Lecher line is closed by a variable capacity.

The maximum power setting of the magnetron must be adjusted by varying the magnetic field and by a corresponding voltage variation. If a permanent magnet is used it is possible to adjust the strength of the magnetic field by a variable interruption of the magnetic flux. One way of varying the field strength in the magnetron is by suitably displacing a ferro-magnetic body so that a variable number of lines of force are short-circuited.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Magnetron for generating ultra-short electro-magnetic waves, characterised by the feature that for the oscillation system an annular hollow body at least almost closed and bounded in a radial direction by two cylindrical casings is provided, the cylindrical casing nearer to the axis being divided along the entire cylinder periphery into two parts by a tortuous slot, said two parts being at different alternating potential but at the same direct potential relative to the cathode located in the axis of the system.

2. Magnetron as in Claim 1, characterised by the feature that the cylindrical casings enclosing the hollow body are made of the same material.

3. Magnetron as in Claim 1, characterised by the feature that the cylindrical casings enclosing the hollow body are made of different material.

4. Magnetron as in Claim 1, characterised by the feature that at least the slotted cylindrical casing nearest to the axis consists of heat resisting material, preferably tantalum.

5. Magnetron as in Claim 1, characterised by the feature that the cylinder nearest to the axis consists of a plurality of rods which are separated from each other by a tortuous slot.

6. Magnetron as in Claim 5, characterised by the feature that the rods are fixed to the end surfaces of the hollow body which are located in an approximately radial direction.

7. Magnetron as in Claim 1, characterised by the feature that at both sides of the hollow body a radially directed plate is arranged for screening off the high frequency field.

8. Magnetron as in Claim 7, characterised by the feature that the cathode consists of a filament extending between the centres of the side plates.

9. Magnetron as in Claim 8, characterised by the feature that the axially located cathode is surrounded by a cylindrical control grid.

10. Magnetron as in Claim 7, characterised by the feature that a side cathode is arranged in the immediate vicinity of the centre point of one side plate and to the opposite side plate a varying control potential is applied.

11. Magnetron as in Claim 7, characterised by the feature that a side cathode is arranged on the outside of the side plate, said plate being provided with a central opening for the passage of the electrons.

12. Magnetron as in Claim 11, characterised by the feature that the side plate where the cathode is located has a variable potential applied to it which differs from that of the cathode.

13. Magnetron as in Claim 7, charac-

terised by the feature that both side plates are electrically connected along the outer periphery in a vacuum-tight manner with the hollow body whereby the generator with the exception of the bushings is enclosed by metal on all sides.

14. Magnetron as in Claim 13, characterised by the feature that inside the cylinder lying nearer to the axis in the immediate vicinity of each side plate an additional plate is arranged which serves as a screen for the constant axial field.

15. Magnetron as in Claim 13, characterised by the feature that external surfaces of the generator are cooled artificially.

16. Magnetron as in Claim 15, characterised by the feature that particularly the external surfaces are artificially cooled along the fastening places of the inner cylindrical casing.

17. Magnetron as in Claim 1, characterised by the feature that a large surface cathode with a cylindrical emitting surface is provided.

18. Magnetron as in Claim 1, characterised by the feature that the axially directed magnet poles of the generator possess a central opening.

19. Magnetron as in Claim 1, characterised by the feature that means are provided by which the volume of the frequency-determining hollow space can be varied at the points of maximum magnetic energy for the purpose of frequency control.

20. Magnetron as in Claim 19, characterised by the feature that at least one point of the outer cylindrical casing is flexible.

21. Magnetron as in Claim 19, characterised by the feature that a metallic piston is arranged to penetrate into the hollow space in an adjustable manner.

22. Magnetron as in Claim 1, characterised by the feature that means are provided by which the volume of the frequency-determining hollow space can be varied at the points of great electrical energy for the purpose of frequency control.

23. Magnetron as in Claim 22, characterised by the feature that at least parts of the side plate are movable in the axial direction.

24. Magnetron as in Claim 1, characterised by the feature that a Lecher line is coupled to the hollow space, the frequency-determining parts of said conductor being adjustable.

25. Magnetron as in Claim 24, characterised by the feature that the conductor is closed at its end by a variable capacity.

26. Magnetron as in Claim 18, characterised by the feature that the magnet poles are constructed so as to be movable in the direction of the central opening.

27. Magnetron as in Claim 1, characterised by the feature that a permanent magnet is used to produce the magnetic field.

28. Magnetron as in Claim 27, characterised by the feature that the magnetic resistance of the flux produced by the permanent magnet can be varied.

29. Magnetron as in Claim 27, characterised by the feature that the field strength of the permanent magnet can be varied by a partial short-circuiting of the lines of force.

30. Devices for producing very short electro-magnetic waves substantially as herein described or as illustrated in the accompanying diagrammatic drawings.

Dated this 27th day of February, 1943.

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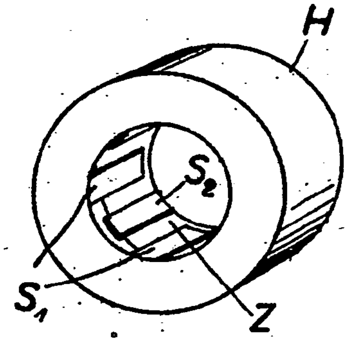

Fig. 1

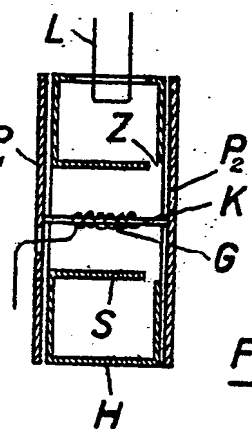

Fig. 2

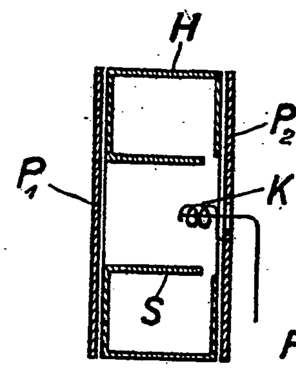

Fig. 3

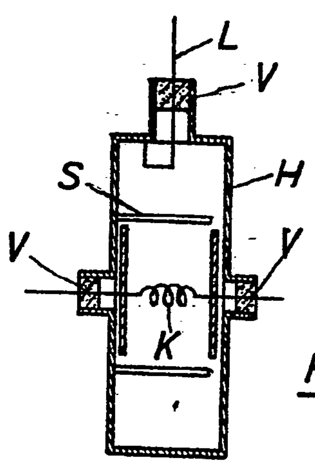

Fig. 4